Putting LANS equations in ICOM

Who? Dr Colin Cotter

When? 19th January 2007

Contents

- Attractive mathematical framework: existence, uniqueness, variational formulation, conservation laws.
- Full dynamical LANS model fits in with our ideas about adaptivity.
- Real modelling success: Turbulence results from Bernard Guerts, MHD results from NCAR, POM results from Mark Petersen show improved performance at modelling variability.

Turbulence closures: two views

What is a turbulence closure for?

- To prevent energy being put into the grid-scale in your fluids code.
- To model the effects of sub-grid dynamics (which may or may not be turbulence).

What does eddy viscosity/LES do?

- Stops small-scales below characteristic lengthscale forming.
- Acts by diffusion.
- Energy and information lost.
- Modern LES: try to recover with dynamic models that include backscatter.

What does LANS do?

- Vortical structures below characteristic lengthscale are passively advected by the flow.
- Circulation theorem/PV conservation.
- No extra dissipation.
- Total kinetic energy

$$\int \frac{1}{2}|u|^2 + \alpha^2 \frac{1}{2}|\nabla u|^2 dV.$$

LANS: not just a new source term

$$\frac{\partial v}{\partial t} + u \cdot \nabla v + (\nabla u)^T v + \Omega \times u = -\nabla p + \mu \nabla^2 v + F,$$
$$\nabla \cdot u = 0, \qquad (1 - \nabla \cdot \alpha^2(\mathbf{x}) \nabla) u$$

- Boundary conditions for elliptic operator: slip, no slip, rotations, outflow, free-surface
- Choice of principle variables (momentum or velocity): stress term (4th-order part?), mass matrix changes.
- Coriolis, geostrophic pressure solver.
- Momentum conservation: new terms.
- Inhomogeneous α changes pressure equation. Sphere.
- Adaptivity: LANS produces lengthscale and timescale.

- Aiming to have LANS in operational code for North Atlantic project.
- LANS version of Diff3D for momentum equation in terms of u using new f90 modules.
- Stress-free boundary conditions.
- Pressure solver to cope with slowly changing α.